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Americas Conference on Information Systems (AMCIS)

December 2007

Business Intelligence Impact Assessment

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BUSINESS INTELLIGENCE IMPACT ASSESSMENT

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Abstract

Organizations strive to enhance performance in an amplified ambiguous environment, by assessing internal working units' efficiency and redesigning organizational structure to achieve this goal. Business Intelligence (BI) is an IT resource that impact both process and overall organization performance. Identifying how BI affects performance has major implications for both organizations that implemented BI and those taking initiatives toward acquiring one. Despite significant efforts and industry investments, this topic received little attention in IS academic research. The goal of this study is to contribute to general body of knowledge in the field, by building on previous literature and theories from both IS and reference disciplines.
The paper develops a framework for assessing the impact of business intelligence capabilities on organization performance, uncertainty, and information processing. According to our review, this is the first study to draw upon Organizational Information Processing (OIPT) and resource-based view of the firm (RBV) theories to investigate a direct association between BI and firm performance.
The contribution of the study is setting a roadmap for further research that builds on existing frameworks and developed instruments.

Keywords: Business Intelligence, Business Intelligence capabilities, Organizational Information Processing, Resource-based view, Organization performance, IT resources, Uncertainty, Information processing

Introduction

A changing formation of customers demand and the advent of new technologies are fostering nontraditional business models that challenge traditional establishments. Such intense combat is taking place as corporate borders are becoming blurrier and interlinked "ecosystems" of suppliers, producers, and customers emerge. In addition, global marketplace and emerging industry structures are forcing agile response to vibrant market conditions while reducing cost.
Business Intelligence (BI) emerged as a promising solution to fulfill strategic demand for both efficiency and effectiveness in examining high volumes of recorded transactions, in order to capture realistic snapshots of business performance and enhancing decision process. The role of BI is more prominent in environments associated with high velocity transaction cycles that impose an extra layer of complexity. In such an environment, the consequences of lacking decisions might have severe impact on the business.

Environment dynamism is a key assumption of information processing theory. According to the theory, overcoming both aspects of internal and external uncertainty is a driving force behind organizations' various designs. These configurations embody: arrangement, strategy, processes, people, compensations and information systems (Galbraith 1973, Tushman and Nadler 1978). Earlier studies found that organizations use quantitative tools and techniques to understand complex relationships among organizational and environmental variables (Simon 1960). Better understanding of these relationships promotes higher level of transparency that facilitates increased performance in an environment predominant with uncertainty, with less amount of information processing.

A survey of Fortune 1000 executives found that 91 percent of respondents viewed "stronger analytical and business intelligence capabilities" as an imperative for continued economic growth (Accenture 2005). Despite such strong indicator, BI has not yet achieved main stream status in IS research. Coarse comparison between professional and academic journals,

conferences, and forums reflect wider gaps in emphasis and research agenda. Negash and Gray (2003) found that BI has established a well defined industry presence. This is reflected in the volume of BI coverage in trade magazines and professional conferences. To the contrary they realized narrow focus on the topic in academia.

In this article we discuss the potential impact of business intelligence capabilities on organization performance, uncertainty, and information processing. The research question for the study is how would business intelligence capabilities impact organization performance, uncertainty, and information processing? In the next sections we extend an overview of BI literature, adopted theories, and research hypotheses. Furthermore, methodology and instrument development are presented along with anticipated contribution and implication of the study.

Background Literature

The Business Intelligence Context

Business Intelligence (BI) environment establishes a virtual repository of historical trends and patterns of behavioral perspectives. It aims at identifying current execution state in order to reverse intolerable deviation or encourage aligned course. Moreover, BI features prospective and predictive roadmap of business trends, It incorporates the tools, methods, and processes needed to transform data into actionable knowledge. This inclination has become critical to all organizations striving to succeed in today's extremely aggressive global landscape. Nurturing an environment, where BI program is properly planned, designed, and executed will ultimately transform into substantial profits, market share, and nimbleness. BI as a broad term could be envisioned as an umbrella of diverse components, assembled in a goal-oriented structure. Nonetheless, almost all definitions share the main premise that include data analysis scheme, even when the term has been defined from multiple standpoints.

One of the objectives of this section is to present various views of vast stakeholders and clarify some of the confusion inherent at this stage of technology adoption. Understanding the purpose and goal of the field enables sound research initiatives to take advantage of domain diversity and richness. This conflicting view of BI is evident in the following definition:

> "BI is neither a product nor a system. It is a generic concept that blends infrastructure databases and applications. It lets business users access, analyze and manipulate data, whether it's financial, sales, marketing, operational/ production, HR-related" (Hart 2005).

Preceding view is supported by Loshin (2003), who declared that BI is neither just a technology, nor is merely practices and methods. According to this conception, it is a combination of the best of both business and technical worlds. Bridging the gap between business and IT groups is a key success factor in any BI program. It helps uncovering the value concealed within a company's information asset, unlock that value and transform into profits.

A simplified view regards Business Intelligence as the process of turning stored data of different activities, through systematic transformation process, into information and then into contextual knowledge. Knowledge obtained about customer needs, customer decision making processes, competition, industry influence, and other environment trends is positively associated with overall performance level. This basic notion has been incorporated in The Data Warehousing Institute (TDWI 2002) working definition of business intelligence:

> "The processes, technologies, and tools needed to turn data into information, information into knowledge, and knowledge into plans that drive profitable business action. Business intelligence encompasses data warehousing, business analytic tools and content/knowledge management"

Other scholars highlighted the goals of BI as to provide the enterprise with a repository of "trusted" data. Moreover, BI processes combine data gathering, data storage, and knowledge management with analytical tools to present complex and competitive information to planners and decision makers (Negash and Gray 2003, Imhoff 2006). This emphasizes that data quality is core for enhancing both quality and timeliness input for decision making.

Classification Scheme

Earlier work on BI could be classified into two broad categories: (1) Conceptual frameworks, and (2) Tested models. Further, it could be categorized based on research methodology into: (1) case studies, and (2) positivist research. Third level of classification could be based on the unit of analysis. While majority of studies use firm level, some investigate at the user or functional level (table 1).

Table 1: Articles Classification

Article	Conceptual Framework Vs. Analytical Model	Research Methodology	BI impact on organization performance	Level of Analysis
Chou et al. 2005	Conceptual paper	Conceptual	Proposed ERP/BI system could improve performance and decision-making capability	Firm
Lönnqvist and Pirttimäki 2006	Hypothetical measurement scale	Argumentative	General measures of BI	Multi-level (Process- firm)
Melville et al. 2004	Conceptual, theoretical, analytical, and empirical studies	Literature Review	IT may contribute to the improvement of organizational performance	Multi-level
Negash and Gray 2003	Conceptual Model	Post – positivist	BI is a strategic tool for corporate performance management	Firm
Cha-Jan Chang and King 2005	Instrument development	Survey	Organizational performance as a function of IS performance	Multi-Level (Process, Firm)
Arnott and Pervan 2005	No Model; Lit review of DSS research	Content analysis	General assessment of DSS research	Firm
Watson et al. 2006	Descriptive approach	Case study	Real-time BI increases revenues and decrease costs	Firm
Reid and Catterall, 2005	No model; Descriptive	Case study	Data quality impact	Firm
Simmers 2004	Conceptual Framework	Argumentative	BI enables organization's sensitivity to vertical, horizontal, and external challenges and opportunities	Firm

Theoretical Framework

In the next sections we present our research model and hypothesis for the study. An overview of organizational information processing and resource-based view theories is outlined with regard to BI, in order to provide support for study hypotheses.

Organizational Information Processing Theory (OIPT) and Business Intelligence

OIPT has been applied to several fields of study ranging from strategy to decision making to information systems (Thompson 1967, Galbraith 1973, Tushman and Nadler 1978). Theory's basic proposition postulates that the greater the uncertainty of a task is, the larger the amounts of information need to be processed during task execution. The manifestation of uncertainty is established by organization's inadequate ability to preplan or define perspective actions. Galbraith's defined uncertainty as the difference between the amount of information required to perform a task and the amount already processed by the organization. According to this view, organizations can reduce uncertainty by employing enhanced planning and coordination schemes. Galbraith stated that "the critical limiting factor of an organizational form is the ability to handle the non-routine events that cannot be anticipated or planned for." He referred to IT resources as vertical information systems that could be one of the forms utilized by an organization to reduce uncertainty.
BI loosely-coupled modular base structure reduces information dependency and associated risk levels. This is achieved through integrated classification, prediction and regression capabilities, custom-built for specific scenarios. In addition the centralized data warehouse enables each unit to have full access to corporate-wide data relevant to decision at hand.
Adopting Galbraith's (1973) dimensions of the vertical information systems, four variables have been identified as applicable to BI capability:

1. Decision frequency, or timing of information flows to and from BI system
2. Scope of data warehouse and operational data stores available to BI system
3. Capacity of BI system to process information and select appropriate alternatives
4. Degree of formalization of the information flow to and from BI system

Smith et al. (1991) review of previous work on OIPT identified the main goal of the theory as attempting to explain organizational behavior by observing organizations in-bound and out-bound information exchange (Knight and McDaniel 1979). They also identified boundary points that represent focal transmitters of environment data inwardly to key decision makers. Aforementioned attribute is a core BI function to have timely analyzed information available for decision makers. Following from previous discussion, our first hypotheses are:

Hypothesis 1a (H_{1a}). *The higher the Business Intelligence capabilities an organization has, the lower inter-unit information processing*

Hypothesis 1b (H_{1b}). *Business Intelligence capabilities reduce amount of information processing requirement, by reducing level of uncertainty*

BI and Uncertainty

Premkumar et al. (2005) examination of various types and amounts of uncertainty revealed that complexity and dynamism are two major dimensions for uncertainty. Their findings strengthen Galbraith's original claim that computerized IS and lateral relations are better choices in high uncertainty situations. Significant amount of environment uncertainty could be mitigated by timely adjustment to customers, suppliers and competitors' influence. Therefore, in order to enhance performance, the organization must match the appropriate methods of information processing, such as BI, with particular uncertainties faced in a dynamic environment. In organizational settings, BI assumes the role of sense-and-response orchestrator.

Additional uncertainty dimensions recognized in the literature include: (1) task complexity that encompasses: interdependence, autonomy, variety, structurability, and intelligibility, and (2) volatility, which includes: rate of change, predictability, exceptions, and controllability. BI's scenario-outcome alternatives capability generates models that take into account both dimensions.

One of the effects of uncertainty is reflected on limiting organization's ability to formulate predefined course of action, and considering alternative forms of structure to compensate for increased levels of uncertainty. Flexible architecture of BI accommodates instantaneous changes to information requirements and analysis. This is considered instrumental in providing guidance through total uncertain circumstances. Further, accurate predictive analytics features serve as reliable tools for decision makers faced with both complex and volatile situations. The monitoring and action capabilities acquaint users with a comprehensive view of environment developments. Accordingly, the second hypothesis is stated as:

Hypothesis 2 (H_2) *Advance Business Intelligence capabilities reduce level of task uncertainty*

Resource-Based View of the Firm and Business Intelligence

As one of widely adopted theories in Information Systems research, resource-based view (RBV) offers contextual IS value to firm's strategy and performance. The theory regards the firm as a possessing collection of resources that are exceptional, nontransferable, hard to reproduce, and non-substitutable. As a consequence, these resources enable the organization to attain competitive advantage and hence lead to superior long-term performance (Barney 1991).

Barney's (1991) foundational work on RBV acknowledged information processing systems, such as BI, as nucleus to organization's cross-level decision making process. Besides, they may hold the potential resources for sustained competitive advantage.

Wade and Hulland's (2004) define resources as assets and capabilities that are available and useful in detecting and responding to market opportunities or threats. BI qualify as both tangible asset and capability, transforming raw data into information of greater value available to the firm.

Ease of replacement of IT systems challenges IT asset status as a contributing resource to firm's competitive advantage. Yet, uniqueness and immobility attributes of the resource are formed by firm's culture, process redesign, and customized deployment. Derived from Grant's (1995) resources classification proposal, business intelligence resources can be classified as: (1) tangible resources comprising physical system and hardware, (2) human resources encompassing both technical and managerial skills, and (3) intangible resources such as knowledge assets and customer profiles and trends.

These modules and their applicability to BI are discussed next:

BI Infrastructure

Physical BI assets consist of organizational data warehouse and departmental data mart(s), operational data stores, Extraction Transformation and Loading (ETL) tools, analytical tools, in addition to, communication and visualization technologies. These technologies are considered major components of overall IT infrastructure that defines organization's stage of innovation and advancement. McKenney (1995) identified IT infrastructure as a key source for achieving long-term competitive advantage. BI infrastructure facilitates innovative corporate initiatives such as new market campaign, customer segmentation and aggregate view of customer's profile across product lines. This degree of freedom enjoyed by organizations invested in these resources gives them leap ahead in becoming first movers and securing pioneering presence ahead of competition. Bharadwaj (2000) found that building such an environment is not trivial to every organization. It involves substantial know-how accumulated over time from lessons learned. Although, individual components of infrastructure are relatively uncomplicated to reproduce and acquire, it's the process of crafting a cohesive BI platform aligned with organization's strategy and business needs that differentiates the system as a contributor to long-term performance. The dynamic nature and continuous improvement of BI infrastructure characterize ambiguity and immobility nature of the resource. This continuous advancement protects its intrinsic value and complete formula from competitors and even from original developers (Cash et al. 1992).

BI Human Resources

Human resources group of business intelligence is a cross-division organization. One skill set includes employees with technical knowledge of architecture, design, and implementation. The other set of skills include those, who developed deep understanding in business processes and managerial competence. Both skill sets accumulated within specific organization setup over extended period of time. The uniqueness of human resources of BI program in an organization is revealed in formation of competency center that oversee all activities of BI. Teams of such competency centers are composed of both IT and non-IT employees. Fusion of organization-specific technical and managerial skills exhibits rarity of resources unlikely to be easily attained or copied.

BI-Enabled Intangibles

Intangible assets are non-physical, non-financial company resources or intellectual properties that add to the overall value and bottom line. From a wider perspective, a subset of such assets include: research and development, intellectual property, customer information and contacts, and brand equity.

For BI, intangibles tend to focus on the strategic "fit" of BI investments, return on investments, opportunity costs, innovation, and the value derived from BI better serving customers. BI capabilities are demonstrated in sustaining intangible resources, especially customer information and contacts, by tracking and predicting customers' preferences and turnover likelihood. Additionally, BI stimulates innovation and branding in response to predicted change that result in direct competitive advantage. Furthermore, BI contributes to organization knowledge assets by acting as both knowledge creation and knowledge repository medium. It's been argued that knowledge assets are organization-dependent, which are hard to copy or replicate. Matusik and Hill (1998) asserted that the relationship between organization knowledge and competitive advantage is moderated by organization's capability to integrate and transfer knowledge.

In summary, prior research utilized resource-based view established that IS resources directly influence competitive position and performance both directly and indirectly through interactions with other resources (Wade and Hulland 2004). The firm's BI infrastructure, BI human skills, and aptitude to power BI for intangible benefits create organization-specific resources that augment other complementary assets to establish BI capability. Previous studies also found that higher performance organizations are successful creating advanced IT capabilities (Bharadwaj 2000).

In this study we argue that advanced BI capabilities have direct impact on organization performance. We outline the third hypothesis as:

Hypothesis 3 (H_3). *The higher Business Intelligence capabilities organization has, the improved organization performance experienced*

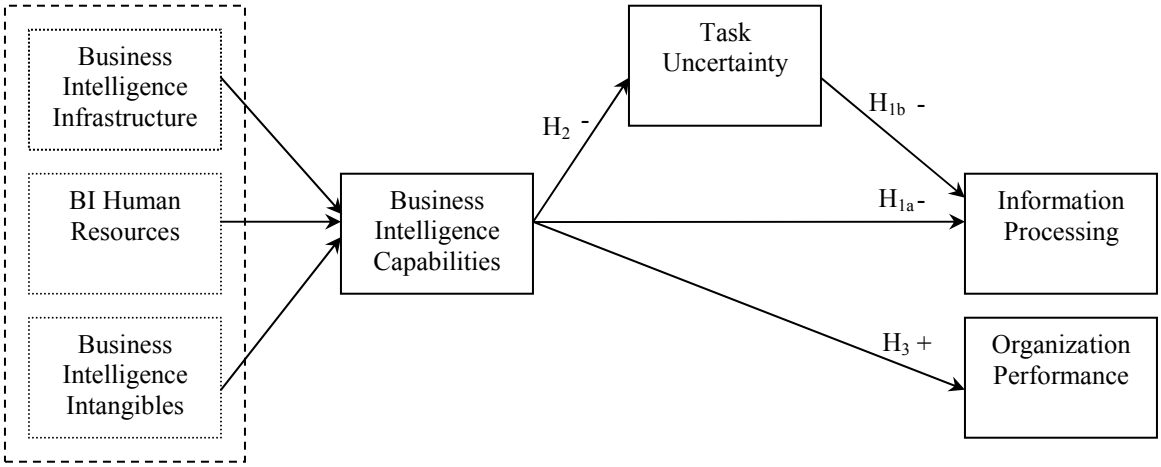

Figure 1: Business Intelligence Capabilities Impact

Research Methodology

Instrument Development

In order to test the research hypotheses, we adopted pre-validated instruments commonly used in IS and other reference disciplines research. Our model includes four main constructs: (1) Uncertainty construct is measured using Duncan (1972), (2) BI Capabilities is measured using Segars and Grover (1998), (3) Organization Performance is measured using Van de Ven and Ferry (1980), in addition to utilizing both Schroder el al. (1967), Van de Ven and Ferry (1980) instruments for measuring (4) Information Processing construct. Next we provide an overview of instruments used and enhancements introduced. We posit that BI capabilities' first order constructs (i.e. infrastructure, HR, intangibles) are solely measures of the construct. They do not have direct influence on endogenous ones.

Organization Performance Measures

In reference to the debate regarding developing appropriate measures of performance, Globerson (1985) argued that developing performance criteria system must satisfy following guidelines:

- Performance criteria must be derived from organization's set objectives
- Performance criteria should allow for comparative assessment against comparable organizations
- Establishing clear objective performance criteria
- Clearly define data collection and calculation techniques of performance criteria
- Ratio Performance criteria are preferred to absolute number
- Performance criteria are under the control of evaluated organizational unit
- Performance criteria are selected through discussions with stakeholders
- Objective performance criteria are preferred to subjective ones
- The value of the performance criteria must be the same or insignificantly different, for the same performance

Van de Ven and Ferry (1980) instrument questions are measured using a five-item scale. The instrument measures perceived performance using eight criteria:

1. Percent of performance targets attained
2. Unit rating on quantity of output
3. Unit rating on quality of work
4. Unit rating on innovativeness
5. Unit rating on reputation for excellence
6. Unit rating on goal attainment
7. Unit rating on efficiency
8. Unit rating on morals

Study participants will be asked to rate the performance of their organization in relation to other comparable organizations based on a list of performance criteria from 1 (far below average) to 5 (far above average)

Uncertainty Measurements

Two uncertainty instruments have received widespread attention. Those include Lawrence and Lorsch (1967) and Duncan (1972). For this study we operate Lawrence and Lorsch's (1967) definition, who classified uncertainty into three levels: (1) lack of clarity of information, (2) long time span of definitive feedback, and (3) general uncertainty factor of causal relationships. We also adopt Duncan's (1972) scale of perceived environmental uncertainty. Three dimensions were identified as measures of uncertainty. The first dimension (dynamism): lack of information regarding the environmental factors associated with a given decision making situation. The second dimension: not knowing the outcome of a specified decision in terms of how much the organization would lose if the decision were incorrect. The third dimension: ability or inability to assign probabilities as to the effect of environmental factors on the success or failure of the organization in performing its functions.

BI Capabilities Measures

In determining measurable variables of this construct, we implemented Bhatt and Grover (2005) IT capabilities framework. Our attempt was to identify those capabilities that are valuable (i.e. have an effect on performance), diversely disseminated across companies (i.e. dissimilar across companies), and inadequately movable (i.e. are hard to obtain externally or build up internally).
In addition we employed Segars and Grover (1998) item measures of planning capabilities. The instrument was slightly modified in order to operationalize BI capabilities construct. The value capabilities of BI are acquired by measuring the ability to share information, innovate, and exploit business opportunities. The competitive capabilities are obtained by measuring BI management capabilities. Finally the dynamic capabilities are captured by measuring BI ability to discover, acquire, and utilize knowledge about resources, opportunities, and optimal configuration of resources to take advantage of opportunities.

Information Processing Measurement

To operationalize information processing construct, Schroder et al. (1967) sentence completion test scale is used. They provided a scoring manual, where subjects are scored using a seven-point Likert scale. An enhanced version of this instrument is developed to capture level of information processing between organizational units in a BI environment. Also in order to have a coherent survey instrument that includes measures for all constructs, information processing is measured by a five-point Likert scale. We also adopted two measures of information processing from Van de Ven and Ferry (1980).

Research Design

In order to test the research hypotheses, the study will identify organizations that are actively engaged in business intelligence program. Thus, the level of analysis will be at the firm level. Since the goal is to capture information from targeted figures within each organization, "key informant" methodology will be employed. It is a common approach in survey research to target respondents based on special qualifications, such as knowledge, experience, and role related to factors under investigation.
Our sampling framework is based on recent regional directories listing organizations in two geographic locations. The listings include information about type, size, earnings and growth trends that span several years. The two geographic locations identified are western and south western regions of the United States. Since these two regions composed of highly competitive organizations in diverse business industries, they form an appropriate match for the study investigation.
We draw a random sample of 5000 companies. The sample covers wide range of organizations attributes. These organizations varied in terms of revenue, size, industry type, and ownership.
As a precautious measure for the study, effort is exercised to reduce impact of industry domain diversity by drawing a sample from relatively comparable group of industries.
A pilot study that includes selected participants from few companies is underway to evaluate the relevance, coverage, and validity of the scales. Developed instrument is sent to nineteen companies' Chef Technology Officers (CTO) and senior VPs with the goal to validate understandability and account for any missing aspects of important measures. A follow up phone interview with the respondents would help clarify constructs and refine instrument.

Data Collection

Data will be collected using online survey instrument from 5000 randomly selected companies CTOs and VPs, from directory listings. Selection criteria for subjects are specified as follows:

- Firm size is larger than 500 employees (Firm size ≥ 500 Employees)
- Firm be in operation for five or more years (Business maturity ≥ 5 Years)
- Organization has significant IT budget (IT budget ≥ $500,000)
- Business Intelligence adopted for at least one year (BI adoption ≥ 1 Year)

After incorporating necessary feedback from pilot study, an introductory email letter including the scope and purpose of the study will be sent out to the larger sample, including a link to the survey. Two weeks later, a second email will be sent to previously contacted companies reminding them to complete the survey and offer assistance with any questions they might have. Our data collection phase is set to four weeks time frame; therefore we test for non-response bias in collected data after four-week period.

Limitations

Current state of the study is considered work-in-progress for assessing BI impact. The data gathering phase to test research hypotheses is in progress. Although the data collection method is clearly specified as part of the research design, stated hypotheses could only be supported after full scale data gathering and analysis phase is completed.
The second limitation represented in the instrument items of adopted measures. Since some of the measures of study variables are based on respondent's perception, there is a chance that this might not reflect actual reality. One of the provisions made is to insure participant's qualifications, by carefully identifying individuals with appropriate background, skills, and experience relevant to items under investigation. In spite of the large sample size targeted, there might still be some risks of getting low response rate. Although this is considered an external factor, measures are put in place to insure that good representative sample will be gathered.
Since this study is conducted at the organizational level of analysis, it's likely to have noticeable differences in our sample. Therefore to isolate BI impact, the study controls for organization size. While other extraneous factors might have slight influence on our study, it's the size of the organization that is expected to have substantial difference.

Conclusion and Implications

This study attempts to evaluate business intelligence capabilities influence on organizational performance, uncertainty, and information processing. Different aspects of BI capabilities and their insinuations have been presented.
Reviewed literature of business intelligence and research standing in the field revealed several competing views of what constitute BI. Some studies focus solely on technical side corresponding to analytical models, data mining techniques, and visualization capabilities. On the other side, further studies argue for a broader view, identifying BI as a framework for enhancing organization decision making process and sustain its competitive advantage. This paper adopted later view, by recognizing BI as a whole process involving technical, organizational, and human facets.
Furthermore, we developed a framework for examining the consequences of BI within its context. This represents a step toward contributing to theory building that encourages more rigorous research in the field. From practical side, the study has implications for practitioners and organizations across various sectors attempting to evaluate their BI program, in relation to comparable competitors. The results of the study also serve as benchmarking tool for existing and potential BI deployments.

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